6. ELECTRICAL POWER AND LIGHTING SYSTEMS

6.1 GENERAL

The design of the electrical installation shall be based on the following:

- Operational safety and reliability.
- Standardization of equipment and material.
- Protection against explosions and fire hazards.
- Economic considerations.

Other aspects like fail-safe features, provision for future extension/ modifications, suitability for the environment and inter-changeability of equipment shall be duly considered.

6.1.1 Operational Safety and Reliability

The design of the electrical installation shall be based on the provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions, including those associated with start-up and shutdown of plant and equipment, and through the intervening shutdown periods.

The design of electrical systems and equipment shall ensure that all operating and maintenance activities can be performed safely. To fulfill these requirements, provisions shall be given for alternative supply sources and supply routes, spare and standby capacity, load shedding, automatic changeover and automatic restarting etc.

The insulating and dielectric materials used in all electrical equipment shall be non-toxic and shall not contain compounds that are persistent and hazardous environmental contaminants.

6.1.2 Standardization of Equipment and Materials

Standardization of materials and equipment shall be aimed at as far as compatible with rational design. Equipment, which will become obsolete in the near future, shall not be purchased nor installed.

Electrical equipment of similar nature and incorporating similar or identical components and of similar or identical construction shall be of the same manufacture.

6.1.3 Protection against Explosion and Fire Hazards

All the area within the battery limits shall be classified for the degree and extent of hazard from flammable material.

For installations having presence of flammable dust, area classification and selection of electrical equipment shall be as per IEC 61241.

For the construction and installation of electrical equipment in hazardous area, all relevant parts of IEC 60079 shall be complied.

Following shall be considered for proper selection of electrical equipment for use in hazardous area:

- Presence of flammable gases/ vapour and/ or flammable dust.
- Area classification in terms of Zones.
- Temperature classification.
- Ingress protection.
- Electrical sub-stations shall be located in non-hazardous areas.

Where it is impractical to install electrical equipment in non-hazardous areas, an appropriate selection of types of protection shall be specified for the different Zones classified according to the likelihood of an explosive atmosphere being present.

Electrical equipment installed in non-hazardous areas within process units shall be industrial type while those installed outside process units shall be industrial/ domestic type depending on the type of installation.

6.1.4 Economic Considerations

Due regard shall be given to the selection and utilization of efficient electrical equipment in order to reduce energy consumption. The use of high efficiency light fittings, intelligent lighting control and high power factor electric drives, selection of low loss transformers etc. shall be evaluated during the detail design stage of the project.

6.2 CODES, STANDARDS AND REFERENCES

The electrical design, manufacture, installation practice and testing of the materials, plant equipment and systems shall conform to the applicable requirement of the latest editions of the following regulations:

- ADDC Regulations for Electrical Installations.
- International Electro-technical Commission (IEC).
- International Standardization Organization (ISO).
- British standard Specifications (BS).
- National Electrical Manufacturing Associations (NEMA).
- Association of German Engineers Specifications (VDE).
- German Industry Standards (DIN).

- Chartered Institute of Building Services Engineers (CIBSE).

6.3 AMBIENT DESIGN CONDITIONS

The prevailing local climatic conditions (Relevant to the design and selection of equipment and materials for the electrical system) are as follows:

- Design temperature (Outdoor)	+ 50° C
- Surface temperature due to solar radiation	+ 85° C
- Maximum ambient air temperature – shade	+ 55° C
- Minimum ambient air temperature	+ 5° C
- Maximum relative Humidity	100%
- Ground temperature (at 1m depth)	+ 35° C
- Environment	Dust storms and High humidity

6.4 POWER SUPPLY ARRANGEMENT

6.4.1 Sources of Power Supply

The medium voltage (11 kV) power supply shall be obtained from Abu Dhabi electricity Distribution Company through the main medium voltage cables network in the site. Medium voltage network to be incorporated within the existing Network and approved by Authorities.

For power supply from ADDC, close co-ordination will be done with ADDC to finalize all parameters of intake power and due consideration shall be given to the expected future planned increase in loads.

Sufficient power capacity will be installed to service the expected two future extension stages.

Electrical power shall be distributed to the buildings from the main low voltage switchboards 400V, fed from the power transformers.

Low voltage shall be 240V single phase or 400V three phase.

The medium voltage (11 kV) power supply shall be obtained from Abu Dhabi electricity Distribution Company through the main medium voltage cables network in the site.
11 kV supply shall be provided for the project via two (2) 11 kV Ring Main Units (RMU's), in order to receive two independent power sources.
The medium voltage switchgear (11 KV switchgear) shall be fed from two (2) RMUs via medium voltage cables and shall be used to feed power transformers required for the project, the switchgear shall

consist of the following:

- Two (2) incoming cells each is complete with 11 kV SF6 motorized withdrawable circuit breaker.
- One (1) bus coupler cell complete with 11 kV SF6 motorized withdrawable circuit breaker.
- One (1) bus riser cell.
- No.'s of outgoing cells (shall be according to the numbers of the transformers), each shall be complete with 11 kV SF6 motorized withdrawable circuit breaker with interlocked earthing switch, breaker outgoing, connected to the power transformer by 12/20 kV XLPE insulated copper cables.

Ring main units and Medium voltage switchgear shall be located in ground floor of the service building.

The preliminary estimated load of the buildings according to area assessment is approximately 5000 kVA based on the buildings area (including administration, kindergarten, male and female schools) shall be 24238m2.

The transformers shall be supplied from the 11 kV medium voltage switchgear via a suitable rated load break switch and 12/20kV(24kV), XLPE/STA/PVC, Copper cable laid on cable tray in cable trench.

6.4.2 Distribution Philosophy

Intake sub-stations for power supply from ADDC and generating units for emergency power generation shall normally be in an electrically centralized location.

Ring distribution system shall be considered for medium voltage network.

The main medium voltage feeders from ADDC shall be duplicated in such a manner that if one of them is tripped or is out of service, the remaining units will take care of the total power.

6.5 CLASSIFICATION OF ELECTRICAL LOADS

Electrical loads shall be classified as performing a service, which is of the following types:

- Vital (i.e. critical).
- Essential (i.e. emergency).
- Non-essential (i.e. normal).

6.5.1 Vital Service

Vital service is a service which, when failing in operation or when failing if called upon, can cause an unsafe condition of the installation, jeopardize life or cause major damage to the installation. This applies to life support systems, emergency and escape lighting, all others low

current systems, and some of the lab. Equipment as advised by client.

Depending on the service conditions, the electrical supply to the vital service shall have to be non-interruptible. Since the faultless functioning of equipment cannot be guaranteed, duplication of sources of power supply and redundancy of equipment shall be built up.

All power circuits and cooling system in NMR laboratory shall be routed through the UPS.

UPS will supply the clean power to the server room, a battery capacity of 60 minutes shall be provided.

For Maintenance/Technical rooms, battery room for emergency power will be provided for backup e.g. pressure testing equipment.

6.5.2 Essential Service

Essential service is a service which, when failing in operation or when failing if called upon, can affect the continuity of operation, the quality or the quantity of product. Therefore the economics of partial or complete duplication of the energy source, of the lines of supply or of the equipment or the introduction of automatic restarting facilities or of changeover facilities or provision of standby energy source shall be evaluated in relation to the consequences of service interruptions mentioned above. The example is power supply to process equipment by means of a duplicate supply system with changeover facility.

6.5.3 Non-essential Service

Non-essential service is a service that is neither vital nor essential and therefore does not require any special measures for safeguarding it. The example is normal lighting.

6.6 ELECTRICAL LOAD SCHEDULE

Summary of electrical loads called the Electrical Load Schedule shall be prepared as early in a project as possible. The Electrical Load Schedule will form the basis for provision of the necessary electrical distribution system capacity.

The following shall be included in the Electrical Load Schedule:

The installed electrical loads with their active power in KW.
Category of load i.e. lighting, power, heating, HVAC, and process loads.
Each type of load shall be summated separately.

A diversity factor shall be applied to each of these summations so that

the Total Connected Load (TCL) and the Maximum Demand Load (MDL) can be calculated.

For the Application Hall: the assumption is that only 75%(diversity factor) of the machines are in operation simultaneously when calculating the maximum demand load at the transformer side although a complete provision for feeding 100% of the machines will be made including panels , cables,…etc.
Using the diversity factor will affect both the no. and rating of the transformers, Main incoming feeder bus ways, and the total load will be decreased by about 25 % (from approx. load of 4.6MVA to 3.5MVA) with 100% redundancy applied the no of transformers will be decreased from 5 no.'s 1500 KVA + 4 no.'s 1000 KVA to 5 no.'s 1500 KVA + 1 no.'s 1000 KVA .

The Electrical Load Schedule shall be updated regularly throughout the design stage of the project.

6.7 SYSTEM VOLTAGE AND FREQUENCY

Selection of Voltage and Frequency

The various voltages shall be decided based on the following factors:

- ADDC supply voltage at battery limits.
- Size and location of loads.
- Future margin and expansions.
- Short circuit levels.
- Availability of switchgear for continuous and short circuit ratings.
- Keeping the number of different voltage levels to a minimum.
- Economic considerations.

The following table indicates the nominal system and standard utilization voltages for particular items of work:

Service	Nominal System Voltages	Remarks
Primary M.V. Distribution	11 KV	
Main, sub-main and secondary distribution	415/240 V	Three phase
A/C System	415 or 240 V	3, 1 phase
Application Hall	415 or 240 V	3, 1 phase
Laboratory	415 or 240 V	3, 1 phase

Indoor/Outdoor lighting	240 V	Single phase
General purpose outlets	240 V	Single phase
Power outlets	415 or 240	3, 1 phase

6.8 SYSTEM POWER FACTOR

The overall system power factor, inclusive of reactive power losses in transformers and other distribution system equipment, shall not be less than 0.95 lagging at rated load.
Static Capacitor Banks shall be provided to improve the power factor. Automatic central capacitors banks to be provided at main low-tension panels bus bars level.
Harmonic filters shall be installed to solve harmonic distortion which effect on the capacitors.

6.9 POWER SUPPLY CAPACITY

6.9.1 General

The capacity of the electrical distribution system shall be capable of supplying continuously 125% of the peak load. While sizing equipment like generators and transformers, direct on line starting and auto-reacceleration of motors shall be duly considered. Future plant load shall be duly taken care in the peak load calculations.

This 25% spare capacity is kept to cater for the possibility of future de-bottlenecking of the plant and to accommodate changes taking place during project design that may involve minor adjustments in electrical loads. This factor of 25% may get reduced to 10%, when the plant is ready to start.

The provision of stand-by capacity shall be considered in relation to safety, reliability and the continuity of plant operation.

6.9.2 Power Supply Units

The number of power supply generator or power transformer units to be installed and their individual ratings depend on many factors, e.g. maintenance requirements, economic size, future load development pattern, unit reliability etc. Sufficient stand-by capacity shall be incorporated to fulfill the requirement of the peak load continuously.

Each circuit of the radial power distribution system shall be rated to cater for the peak load requirements on continuous basis so as to facilitate the isolation of individual circuits for the purpose of testing, maintenance and faulty conditions.

For ring distribution, the ring-main cable shall be rated to cater for the peak load requirements continuously on the basis that the ring is open at one end.

6.10 SHORT CIRCUIT CAPACITIES

All equipment shall be capable of withstanding the effects of short circuit currents (initial symmetrical short circuit current and peak short circuit current) and consequential voltage arising in the event of equipment failure or equipment faults.

Each short circuit interrupting device shall be designed to have rated breaking capacity equal to or higher than the maximum value of short circuit current calculated at its location.

For power intake switchboards, close co-ordination will be done with ADDC and due consideration shall be given to the expected future planned increase in short circuit level.

Short circuit rating of generator switchgear shall be calculated taking into consideration the maximum number of generators simultaneously in operation including future expansions.

All switchgear and bus-bar ducting shall withstand the maximum fault current for a minimum period of one second.

Sizing of medium voltage cables shall be based on the short circuit withstand capacity for a duration dictated by the protection system.

6.11 ISOLATION PHILOSOPHY

All packaged equipment will have provision to disconnect from its power supply locally.

All motors will have provision to be disconnected from its power supply either locally or at the MCC.

All power feeders will be isolated through the use of breakers and/or switches in the switchgear/MCC/switchboard.

All lighting panels will have a breaker to disconnect it from its power supply.

All control panels will have a switch to disconnect it from its power supply.

Motor stop circuit will be hard-wired from MCC via interposing relays to the facilities safeguarding (emergency shutdown) system.

Emergency shutdown of equipment, if required, will be possible irrespective of any PLC/microprocessor failure.

Machines & equipment at application halls shall be fed from bottom with stub–up outlets & supply points with connecting means.

Lab benches and fume cup-board shall have built-in standard power boxes of the new QC-LAB.

6.12 EARTHING

The earthing system shall consist of furnishing and installation of the earthing system complies with ADDC, BS 7430 and BS 7671 standards.

Ring earth shall be provided at machines in application hall and above false ceiling for Labs.

Clean earth shall be provided for telecommunications and low current systems.

Earthing for NMR Laboratory shall be separate from power earthing.

The earthing system shall provide to ensure protection of personal against electrical shocks from faulty electrical circuits to protect equipment from damage and achieve proper operation of protective devices on earth faults.

Earth leakage shall be provided for each & all individual load circuit.

6.13 LIGHTNING SYSTEM

Lighting protection system shall be provided to achieve the requirements of BS EN 62305.

6.14 ELECTRICAL PROTECTION SYSTEM

The electrical system shall be equipped with reliable automatic protections.

The type and characteristics of protective devices shall be selected according to the application.

Microprocessor based numerical protection system in combination with Power Management System shall be considered.

Protective relays shall have one or more of the following basic requirements:

- Fully solid state.
- Multi-function where appropriate.
- Intelligent and dynamic (e.g. self-adjusting characteristics for thermal imaging).
- Remote monitoring interface.

The automatic protective systems shall be designed to achieve selective isolation of faulted equipment without delay, which shall be within a time corresponding to the short-circuit current withstand capability of equipment, system stable operating limits and the maximum fault clearance times.

6.15 ELECTRICAL EQUIPMENT

6.15.1 General

All electrical equipment shall be suitable for the site and environmental conditions as specified in the Project Specifications.
The outdoor equipment shall be protected with suitable sun-shelter and the ingress protection for the equipment enclosure shall be minimum IP-55 as per IEC 60529. Sheds with open sides shall be considered as outdoor installations.

The indoor equipment shall be installed in rooms having HVAC systems. The ingress protection for the equipment enclosure shall be minimum IP-42 as per IEC 60529. However, the indoor equipment shall be designed for satisfactory continuous operation even if HVAC system fails.

High humidity is experienced in all areas and condensation will occur on all equipment during some period of their lifetime and therefore all components, nuts, bolts and washers etc. shall be of corrosion resistant material and shall be tropicalised. Anti-condensation heaters shall be provided in all electrical equipment like switchgear, UPS systems, motors, generators etc.

Equipment like main generators, emergency generators, AC UPS system, DC UPS system, batteries and switchboards shall be installed in non-hazardous areas. Only in exceptional cases, these can be installed in hazardous areas in specially designed rooms.

6.15.2 Diesel Engine Driven Generators

The emergency generators shall feed the following loads:

- Electrical loads essential for safe shutdown of the plant.
- Emergency lighting.
- Plant instruments, as applicable and specified by the process

equipment specialist.
- Communication equipment.
- Fire and gas detection system.
- UPS systems (AC & DC).
- Fire fighting equipment.
- Smoke control system's equipment, stairs/lifts, air pressurization fans, fire doors locking systems … etc.
- Loads critical for personnel safety.
- Fume hoods and critical spot exhaust.
- All exhaust and ventilation systems' equipment for application halls, warehouses, laboratories and lavatory areas.

The generators shall be sized to have at least 10% spare capacity for future. Motor starting requirements and UPS loads shall be duly considered for sizing of generators.

6.15.3 Power Transformers

For increased fire risk locations and indoor installations dry-type transformer shall be used.

The transformer rated duty shall be selected as at least 80% of the nominal continuous running kVA as calculated in the Electrical Load Schedule.

In the case of doubly fed switchboards each transformer shall be sized on the assumption that it is taking the entire load on the switchboard, i.e. one feeder is out of service and the bus-bar section circuit breaker is closed.

6.15.4 Switchgear

General

Switchgear shall be of the compartmentalized metal clad type (IEC-Form 4 / Type 6) design to minimize any risk of developing a short-circuit or the propagation of a short-circuit and to ensure personnel and operational safety during all operating conditions, inspections, maintenance, the connection of main, control and auxiliary cables and the equipping and commissioning of spare panels whilst the switchgear is live and in operation.
All switchboard components e.g. circuit breakers, main horizontal & vertical bus bars, bus bar joints, bus bar supports etc. shall be designed to withstand the maximum expected short circuit level for a minimum time of 1 sec.
All switchgear and associated equipment fed from generators and transformers shall be rated at least 125% of the rating of maximum number of generators and/or transformers simultaneously feeding it

including future expansions. The bus-section circuit breaker shall have rating equal to that of the rating of the largest incomer circuit breaker.

MV Switchgear

The breakers shall be SF6 or Vacuum (subject to ADDC-approval). MV switchgear shall be of withdrawable type.

LV Switchgear

Components of LV switchgear shall be standardized as much as possible and selected in accordance with the current ratings.

Main LV switchgear shall be of withdrawable type.(refer to ADNOC standard specifications.

Configuration of Switchboards

For all switchboards, the number of sections shall be two and each bus-section shall be provided with 100% rated incoming circuit. Only in very special cases, switchgear with three sections shall be provided and each bus-section shall be provided with 50% rated incoming circuit.

For interruptible, maintained supplies to vital services, a separate switchboard shall be provided. The normal feeder to this switchboard shall be derived from the mains power system and the standby circuit from an emergency diesel generating set. An automatic changeover system shall be provided to changeover to the standby circuit in case of mains failure.

For non-essential loads, switchgear with one bus-section with 100% rated incoming circuit shall be considered.

Operating Philosophy of MV and LV Switchboards

In the majority of plants, the normal operating position of switchboard incoming and bus-section circuit breakers shall be as follows:

- For MV and LV switchboards the bus-section circuit breakers shall be operated normally open, except on switchboards, which are the only source of supply i.e. at LV generator switchboards. The incoming circuit breakers shall be operated normally closed. An auto-changeover scheme shall be employed to close the bus-section circuit breaker automatically restoring the loss of supply to the section, which has lost supply from its feeder. Facility for momentary paralleling/ synchronization, as applicable, shall be provided for the incoming feeders for changeover schemes.

When a section of bus bars or a feeder transformer is being taken out of service, the normal operation of the bus-section circuit breakers shall be a manual function, carried out locally at the switchboard for the purposes of maintenance.

The configuration of intake, power plant and distribution switchboards shall permit one section of the switchboard to be taken out of service while still maintaining the normal plant operations.

Spare Cubicles

MV switchboards shall have at least two spare outgoing cubicles on each busbar section. The type and rating of the spare cubicles shall be decided based on the type and rating of feeders provided in the MV Switchgear. Subject to ADDC approval/requirements.

LV switchboards shall have spare breakers, etc., for the possible future installation of additional outgoing circuits equivalent to approximately 20% of the number of circuits initially utilized, with a minimum of one circuit of each size and type of consumer (e.g. outgoing static feeder, outgoing motor feeder).
All spare breakers shall be fully equipped.

Ring-main Units

The ring-main units shall be designed strictly as one simple ring. The simple ring shall not have any interconnectors to other sources outside the ring. The ring shall only be supplied at its two "ends".

Ring-main units (RMU) shall be specially designed for the purpose, and each such unit shall only consist of two incomer switches and one or two outgoing circuit breaker.

The ring-main units shall be located inside the sub-station in a separate M.V. room(s).

The unit shall incorporate transformer earth switch.

6.15.5 Bus-bar Ducting

The continuous and short-circuit rating of bus-bar ducting shall be same as that of switchgear, transformers and generators to which these are connected.

For LV systems where the current rating exceeds 1600 Amp, interconnection of equipment shall be through bus bar ducting instead of cables. (Subject to ADDC/Company approval)

6.15.6 AC UPS System

AC UPS system shall be provided for continuous process loads and instrumentation system requiring uninterruptible maintained AC supply. Following loads shall be connected to the AC UPS system:

- Fire and gas system.
- Local panels for critical packages.
- Instrumentation as applicable.
- Telephone system.
- Communication equipment.
- Laboratory equipment – as required by equipment specialist & approved by company.

The configuration of UPS System shall be parallel redundant. 2 Nos. 50% loaded back-up battery banks shall be provided. The UPS system shall also be provided with stabilized static and maintenance bypass.

10% margin in capacity shall be kept for future requirements.

AC Distribution Board shall have at least 10% spare outgoing feeders for future use.

6.15.7 DC UPS System

DC UPS system shall be provided to feed the following:

- Switchgear control.
- DC motors, if applicable.

The DC UPS system shall comprise of 2 Nos. 100% rated rectifier/ charger units and 2 Nos. 50% loaded back-up battery banks.

10% margin in the capacity shall be kept for future requirements.

DC Distribution Board shall have at least 10% spare outgoing feeders for future use.

6.15.8 Batteries

Batteries shall be of adequate capacity to meet the back-up requirements for the required duty cycle and to take care of future load margin of 10%.

While sizing the batteries, temperature correction factor and ageing factor shall be duly considered.

For both AC UPS and DC UPS system, Ni-Cd batteries shall be specified.

6.16 CABLES AND WIRES

<u>General</u>

Multi-core cables shall be given preference to single core cables. However, single core cables may be used for practical and economic reasons.

The power and lighting cables shall be sized based on maximum continuous current; voltage drop, system earthing and short circuit withstand criteria. The de-rating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil, depth of laying etc. shall be considered.

Double overall diameter spacing shall be considered where ever space allowance is available to save grouping duration applications.

Cables for capacitor banks shall be sized for minimum 135% of the rated capacitor current.

All power and control cables within project area wideness shall be in continuous lengths without any splices or intermediate joints.

6.16.1 MV Cables

Three core MV cables shall be of copper conductors type, cross-linked polyethylene (XLPE) insulated, single galvanized steel wire armoured and PVC oversheathed.

6.16.2 LV Cables

Multi-core power, lighting and control cables shall be cross-linked polyethylene or PVC insulated, armoured or unarmoured and PVC sheathed.

<u>In application hall</u>: cables shall arrive to the machines in service tunnels and trenches in the ground in order to keep the space above the machines as free as possible. The trenches shall be covered with movable lids.

<u>In laboratories</u>: cables shall arrive to the benches in columns that shall be covered by panels; all electrical cables shall be in channels either in benches or on the walls. Easy and flexible extensions possibilities are important.

Care shall be taken for no metal parts around magnet in NMR laboratory (4m apart).

6.16.3 Earthing Cables

Earthing cables for both aboveground and underground shall be PVC sheathed, coloured yellow/green.

6.16.4 Flexible Cables

Flexible cables for voltages up to 450 V to earth shall be heavy duty neoprene rubber insulated, PVC sheathed. The flexible cables shall be used for welding sets, portable equipment, hand tools, hand lamps, winches and hoists etc.

6.16.5 Wires

Wires shall be PVC insulated in accordance with IEC 60227.

6.16.6 Cables with Fire Withstand Capabilities

Cables required to continue in operation for a specified time during a fire e.g. cables for emergency shutdown systems shall have increased fire withstand capabilities. All cables and wires shall be of LSF types.

6.16.7 Cable Accessories

Cable glands shall be selected to suit the type of cable and termination box/ enclosure and shall be of appropriate type of protection for the hazardous area. Effective earth continuity shall be ensured between the cable armour and the gland plate or the internal earth terminal.

6.17 REMOTE CONTROL UNIT

Each motor shall be provided with a key operated Remote Control Unit (RCU) in the field near the motor for starting and stopping purpose. Sun-shelter shall be provided to protect the outdoor RCUs.

Based on the control requirements, the RCU shall be provided with start/ stop push button, ammeter, auto/ manual and local/ remote selector switches, etc.

For machines with built-in or side mounted control station provided with local disconnector means, cables shall reach up to it’s relavent connection points.

6.18 LIGHTING EQUIPMENT

General

All systems covered under this title shall comply with CIBSE code.

Fluorescent lighting shall, in general, be used for illumination, high bay luminaries shall be employed at application halls and warehouse.

High frequency electronic ballast shall be employed where ever applicable as cost effective.

Flood lighting shall be used for the open areas outside around the process and production plants. High-pressure discharge lamps shall be used for flood lighting, most probably metal halide lamp typs.

All outdoor lighting shall be controlled by means of photoelectric cell with manual over riding control and BMS- programmable software.

Switching System:

The lighting switching system shall be done using different methods as follows:

Local switches

For technical areas such as electrical rooms, IT rooms, storage, etc shall be switched using local switches. Weatherproof type switches shall be used in wet/technical areas.

Programmable Lighting control System

For office areas, the switching system will be Through this lighting control system, all lighting shall be controlled such that unnecessary lights shall be switched 'Off' based on occupancy. Also lights redundant due to sufficient daylight shall be switched 'Off' based on light sensor and time schedules.

Detection will be via intelligent movement sensors strategically placed to give the required coverage for all possible entry and exit upon sensing a movement within any area the light in that area shall be switched on till the movements is not sensed and shall switch off after preset time.

Lighting control at various areas shall be generally as indicated hereunder:

1. **Common areas** (Corridors, lobbies, Toilets, waiting, etc): Lighting control shall be by timer channels and Intelligent Motion Sensors. All lights shall be normally ON during working hours. All lights shall be normally OFF during non working hours and on holidays when no movement is detected, and when movement is detected at any area, lighting at that area shall be turned ON.

2. **Staircase:** Lighting control shall be by timer, sensor and intelligent push button switch. All lights, which shall be ON by the push button,

switch shall be automatically turned OFF after a predetermined time period which is programmble by the end user.

3. **Offices, Laboratories, Application Hall**: Lighting control shall be by timer channels, sensor and intelligent lighting control switch in each area. Lights in individual area shall be turned ON/OFF using the intelligent switch during working hours; however the system switches shall be over ridden by timer schedules during non working hours and on holidays. All lights in offices shall be normally OFF during non working hours and on holidays; however it can be overridden by the intelligent switch and shall be turned off automatically at the end of a pre determined time period or at a particular time which is programmable by the end user.

4. **Entrance at ground floor, External lighting and recreation facilities: Ground floor entrance hall, external lighting and recreation facilities shall be switched on/off based on available daylight.**

In general the system shall be completely programmable; the programming shall be implemented via a computer with access level passwords.

6.18.1 Plant Lighting

Plant lighting shall comprise of following:

- Normal lighting.
- Emergency lighting.
- Escape/ Critical lighting.

Normal and emergency lighting shall be fed by AC supply while escape/ critical lighting shall be fed from central battery system.

For both Zone-1 and Zone-2 hazardous areas, the preferred form of illumination shall be fluorescent lamps with type of protection Ex-e.

If high-pressure discharge lamp fittings are needed in hazardous areas then they shall be of the Ex-d type only. An isolating switch shall be included inside the fitting to prevent the light fitting from being

energized when it is not fully assembled.

For standardization purposes, the same type Ex-d or Ex-e lighting fixtures shall be used whether classified Zone-1 or Zone-2.

6.18.2 Application Hall

The view points shall have very good light (day light if possible).

There shall be yellow lighting (not white).

There shall be no light shadow area.

For W&C cluster: good light around the line will be provided, especially around the extruders head/die and above work benches and writing tables.

6.18.3 Building Lighting

Lighting fittings in closed buildings, which are classified as non-hazardous areas, such as offices, control rooms, sub-stations, shall be fluorescent bi-pin, switch-start type, industrial or domestic type.

Normal halogen luminaries shall be used for NMR laboratory; florescent lighting shall not be used in the area considered for the magnet.

Care shall be taken to do not direct intense spotlight onto the magnet, which could change the surface temperature, Lights are generally not recommended within a radius of 10"rom the magnet. (all in co-ordination with magnet manufacturer).

Consideration shall be given to the relative placement of lights to the air conditioning inputs, which mostly contain the temperature sensors for the air conditioners.

6.19 POWER AND CONVENIENCE OUTLETS

Power Outlets: Suitable types of local fused switches are provided adjacent to electric Process, Application, and Laboratory Equipment. (plug-in bus ways along machines lines with local disconnecting means to be studied).

Separate power circuit shall be provided for Magnet in NMR laboratory.

Convenience Socket Outlets: Different types of switched wall socket outlets with pilot lamp are properly distributed to maintain adequate supply points for different types of fixed and/or portable

electric appliances.

Exterior locations or in areas continual dampness, the sockets shall be watertight pattern with watertight caps and approved gaskets (IP 44min). The sockets shall comply BS EN 60309-2.

Socket outlets, conduits and boxes are totally segregated from any other system.

Floor box Outlets: Floor box outlets are used where socket outlets can't be used and shall contain socket outlets feed from normal and UPS supply (where required) in areas.
The electrical distribution in server room will be compost of clean (from UPS) and dirty (NET) power outlets, additionally a power socket with 32A power outlet has to be installed for each rack.

For Labs supply points, the standard power boxes built into the work benches and fume cupboard shall be used.

6.0 METHODS OF CALCULATIONS

6.20.1 Installation Dimensioning

The following steps show the procedure to follow for the correct dimensioning of the plant.

a. Load Analysis

- Definition of the power absorbed by the loads and relevant position;
- Definition of the position of the power distribution centers (switchboards);
- Definition of the paths and calculation of the length of the connection elements;
- Definition of the total power absorbed, taking into account the diversity factors and load factors.

b. Dimensioning of Transformers and Generators

With margin connected to future predictable power supply requirements (by approximation from 15 - 30%)
100% redundancy will be considered for transformers.

c. Dimensioning of Conductors

- Evaluation of the current (Ib) in the single connection elements;
- Definition of the conductor type (conductors and insulation

materials, configuration);

- Consider others derating factors in view of methods of installations.

- Definition of the cross section and of the current carrying capacity;
- Calculation of the voltage drop at the load current under specific reference conditions (motor starting).

d. Verification of the voltage drop limits at the final loads.

e. Short-Circuit Current Calculation

Maximum values at the busbars (beginning of line) and minimum values at the end of line.

f. Selection of Protective Circuit-Breakers with:

- Breaking capacity higher than the maximum prospective short-circuit current;
- Rated current In not lower than the load current Ib;
- Characteristics compatible with the type of protected load (motors, capacitors...).

g. Verification of the protection of conductors:

- Verification of the protection against overload: the rated current or the set current of the circuit-breaker shall be higher than the load current, but lower than the current carrying capacity of the conductor: Ib ≤ In ≤ Iz
- Verification of the protection against short-circuit: the specific let-through energy by the circuit breaker under short-circuit conditions shall be lower than the specific let-through energy which can be withstood by the cable:

  I2t ≤ k2S2
- Verification of the protection against indirect contacts (depending on the distribution system).

k. Verification of the coordination

With other equipments (discrimination and back-up, verification of the coordination with switch disconnections)

6.20.2 Load analysis

Induction Motors

The full-load current Ia supplied to the motor is given by the

following formulae:

3-phase motor: $$I_a = \frac{P_n}{\sqrt{3}\, U \cos\varphi\ \eta}$$

1-phase motor: $$I_a = \frac{P_n}{U \cos\varphi\ \eta}$$

where

Ia : current demand (in amps).
Pn : nominal power (in kW of active power).
U : voltage between phases for 3-phase motors and voltage between the terminals for single-phase motors (in volts).
η : per-unit efficiency.
Cosφ : power factor.

Motor-Starting Current

Starting current (Id) for 3-phase induction motors, according to motor type, will be:

- For direct-on-line starting of squirrel-cage motors:

  Id = 4.2 to 9 In for 2-pole motors
  Id = 4.2 to 7 In for motors with more than 2 poles (mean value = 6 In), where
  In = nominal full-load current of the motor,

- For wound-rotor motors (with slip-rings), and for D.C. motors:

  Id depends on the value of starting resistances in the rotor circuits:
  Id = 1.5 to 3 In (mean value = 2.5 In).

- For induction motors controlled by speed changing variable-frequency devices, assume that the control device has the effect of increasing the power (kW) supplied to the circuit motor (i.e. device plus) by 10%.
- Reduced voltage starting method shall be considered as per local regulations.
- Voltage-dip calculation shall be checked for big motors operated on 400V level.

Direct-Current Motors

D.C. motors are mainly used for specific applications which require very high torques and/or variable speed control (for example machine tools and crushers, etc.).

Power to these motors is provided via speed control converters, fed from 230/400 V 3-phase a.c. sources.

The operating principle of the converter does not allow heavy overloading. The speed controller, the supply line and the protection are therefore based on the duty cycle of the motor (e.g. frequent starting-current peaks) rather than on the steady-state full-load current.

For powers ≤ 40 kW, this solution is progressively replaced with a speed changing variable-frequency device and an asynchronous motor. It is still used for gradual starters and/or retarders.

Resistive-Type Heating Appliances

The power consumed by a heating appliance is equal to the nominal power Pn quoted by the manufacturer (i.e. cosφ= 1)

The currents are given by:

3-phase case: $$I_a = \frac{P_n}{\sqrt{3}\,U}$$

1-phase case: $$I_a = \frac{P_n}{U}$$

Where U is the voltage between the terminals of the equipment.

Fluorescent Lamps and Related Equipment

The power Pn (watts) indicated on the tube of a fluorescent lamp does not include the power dissipated in the ballast.

The current taken by the complete circuit is given by: $$I_a = \frac{P_n + P_{ballest}}{U\cos\varphi}$$

where U = the voltage applied to the lamp, complete with its related equipment.

- cosφ = 0.96 for electronic ballast for most fittings.

If no power-loss value is indicated for the ballast, a figure of 25% of Pn may be used.

6.20.3 Sizing of Power Cables

For a correct dimensioning of a cable, the following will be done:

- Choose the type of cable and installation according to the environment;
- Choose the cross section according to the load current;
- Verify the voltage drop.

The international reference Standard ruling the installation and calculation of the current carrying capacity of cables in commercial and industrial buildings is IEC 60364-5-52 “Electrical installations of buildings – Part 5-52 Selection and Erection of Electrical Equipment-Wiring systems”.

The following parameters are used to select the cable type:

- Conductive material.
- Insulation material.
- The type of conductor.

Methods of Installation

To define the current carrying capacity of the conductor and therefore to identify the correct cross section for the load current, the standardized method of installation that better suits the actual installation situation shall be identified.

From Tables in the mentioned reference Standard it is possible to identify the installation identification number, the method of installation and the theoretical current carrying capacity of the conductor and any correction factors required to allow for particular environmental and installation situations.

6.20.4 Determination of Voltage Drop

Voltage drop in mv/A/m given by cables/wires manufacturer shall be used.

For prefabricated pre-wired ducts and bus trunking, resistance and inductive reactance values are given by the manufacturer.

6.20.5 Determination of the short-circuit current

In order to determine the short-circuit current the “ohmic impedance method” can be used.

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Short Circuit Calculations

ICC	=	Short Circuit Current (Sym. R.M.S value)	=	$\frac{U}{\sqrt{3} * ZCC}$
ZCC	=	Total impedance per phase	=	$\sqrt{[(\sum R)2 + (\sum X)2)]}$
U	=	Line voltage of three phase system	=	$\sqrt{3} * ZCC * ICC$
PCC	=	Short Circuit Power Level	=	$\sqrt{3} * U * ICC = \frac{U2\ldots}{ZCC}$
ZLV	=	$ZMV * \frac{ULV2}{UMV2}$		
ZMV	=	$ZLV * \frac{UMV2}{ULV2}$		
ULV	=	Low Voltage	=	0.24 or 0.415 kV
UMV	=	Medium Voltage	=	11 kV

- **Upstream Network**

$$Z = \frac{U2}{PCC}$$

PCC = 500 MVA (assumed)

- **Transformer**

$$Z = \frac{U2 * E}{Pn * 100}$$

E = Transformer voltage impedance
= 5.75 (for 1 000, 1 500 and 2 000 KVA Transformer Rating

PCC = Transformer Rating

6.20.6 Coordination between conductor and protective device

According to BS7671 (IEE Wiring Regulations):

The characteristics of each protective device shall satisfy the following conditions:

- Its nominal current or current setting (In) is not less than the design current (Ib) of the circuit, and
- Its nominal current or current setting (In) does not exceed the lowest of the current-carrying capacities (IZ) of any of the conductors of the circuit, and
- The current (I2) causing effective operation of the protective device does not exceed 1.45 times the lowest of the current-carrying capacities (IZ) of any of the conductors of the circuit.

6.20.7 Lighting System

DIALux 4.1 - The Software Standard for Calculating Lighting Layouts – will be used

Maintenance Factor as per CIBSE Code:

The maintenance factor (MF) is a multiple of factors
MF= LLMF x LSE x LMF x RSMF

LLMF : Lamp Lumen maintenance factor
LSF : Lamp survival factor
LMF : Luminaire maintenance factor
RSMF : Room maintenance factor

For operation time 1000h, using fluorescent lamps then LLMF= 0.94, LSF = 1

- For luminaire class (D): Enclosed (IP2X)
- Environment Normal
- Time between cleaning one year.

Then LMF = 0.82

For room index medium- large, using direct/indirect luminaire distribution
Then RSMF = 0.88

Then the calculated average maintenance factor will be considered as (0.7)